PD 686-035

SeaWinds Experiment

Cleaniness/Contamination Control Requirements

July 1994

Jet Propulsion Laboratory
California Institute of Technology

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DUMMY FOREWORD/NOTE

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SECTION 1: INTRODUCTION

1.1 SCOPE

The objective of the SeaWinds Scatterometer Cleanliness/ Contamination Control Program is to ensure mission success, in a cost effective way, without contamination induced deleterious effects to either the Seawinds or adjacent scientific instruments.

This plan is applicable to the design, fabrication, assembly, testing, transportation and storage of the Seawinds flight hardware. Ground Support Equipment (GSE) and Special Test Equipment (STE) are required to conform to the requirements of this Plan from the standpoint of not presenting a contamination problem under any of the conditions imposed during usage with the Seawinds. Particular care, therefore, must be taken to minimize the outgassing of GSE and STE co-located with flight hardware inside vacuum systems during testing, so as to fulfill the requirements of contamination control.

1.2 PURPOSE

This Plan and the Seawinds Reliability Assurance Plan, XXX-XX, establish the requirements for the cleanliness/contamination control program. Each cognizant engineer shall be responsible for contamination control which meets the intent of this Plan. The details for implementation of cleanliness/contamination control shall be incorporated as part of the Assembly and Inspection Data Sheets (AIDS) planning documentation, or equivalent Contractor assembly instructions, by the various responsible organizations supporting the Seawinds Project.

SECTION 2: APPLICABLE DOCUMENTS

2.1 GENERAL

The documents listed in section 2.2, of the latest issue, form a part of this document to the extent specified herein. In case of conflict between a referenced document and this document, this document shall govern.

2.2 GOVERNING SPECIFICATIONS

FED STD - 209D	Clean Room and Work Station Requirements, Controlled Environment
PD 686-031	Reliability Assurance Plan For Seawinds
PD 686-032	Quality Assurance Plan For Seawinds
PD 686-037	Safety Plan For Seawinds
D-8208	Spacecraft Design and Fabrication Requirements for Electronic Packaging and Cabling
MIL-STD-1246, Rev. B	Cleanliness Levels and Contamination Control Program

2.3 REFERENCE ONLY

FS504574, Rev. C	General Cleaning Requirements for Spacecraft Propulsion Systems and Support Equipment
NASA JSC SP-R-0022A	Specification Vacuum Stability Requirements of Polymeric Material for Spacecraft Application
ASTM E1235-88	Standard Test Method for Gravimetric Determination of Nonvolatile Residue (NVR) in Environmentally Controlled Areas for Spacecraft
GSFC-TLS-PR-7324-01	Contamination Control Procedure for the Tape Lift Sampling of Surfaces

SECTION 3: PROGRAM CONTAMINATION REQUIREMENTS

3.1 SELF-CONTAMINATION SUSCEPTIBILITY REQUIREMENTS

These requirements are limitations on the quantities of contamination that SeaWinds may have on its surfaces, molecular and particles, or outgas from its materials and components. Such requirements are based on the allowed degradation of its own contamination-sensitive surfaces due to contamination.

The specific requirements are: not determined, but assumed very trivial, i.e. no surfaces sensitive at credible levels of contamination have been identified by the project.

3.2 CONTAMINATION COMPATIBILITY REQUIREMENTS

These requirements are limitations on the quantities of contamination that SeaWinds may have on its surfaces, molecular and particles, or outgas from its materials and components. Such requirements are imposed on each payload instrument by the spacecraft system Integrator, or equivalent, for the protection of the other payload instruments and the spacecraft systems.
The specific requirements are: none (at this writing)

SECTION 4: METHOD OF CONTROL OF CLEANLINESS/CONTAMINATION FOR DESIGN, FABRICATION,ASSEMBLY AND TEST OF THE Seawinds

4.1 GENERAL

Elements and components of the Seawinds shall be designed, fabricated, cleaned, assembled, and tested in accordance with the cleanliness/contamination control policies of this Plan.

4.2 APPROACH

In order to meet the stated objective of the SeaWinds Cleanliness/ Contamination Control Program in the absence of any specific requirements, the approach taken is to implement a reasonable degree of contamination control. Particle cleanliness is to be achieved by cleaning and by environmental protection (clean rooms, packaging, etc.). Surface molecular cleanliness is to be realized by the same techniques, plus vacuum conditioning (a modest vacuum bake out). All individual mechanical parts, components, etc. shall be cleaned at the lowest level of assembly and handled in such a manner as to minimize the accumulation of contaminants as assembly progresses. Molecular outgassing is to be controlled by material selection, by venting design and by vacuum conditioning. All of these procedures are applied by process control only; there are no post-procedure acceptance criteria on cleanliness. However, certain cleanliness measurements at the SeaWinds system (i.e. the instrument) level are to be executed and documented.

4.3 DESIGN REQUIREMENTS

4.3.1 Materials

Selected materials in designs shall be compatible with at least one standard cleaning procedure and solvent (D-8208 or FS504574, Rev. C, as appropriate). Non-metallic materials and surface coatings which outgas less than 1.0 percent total weight loss (TWL) and less than 0.1 percent volatile condensable materials (VCM), shall be used (SP-R-0022A). Exceptions based on the usage of small quantities shall be reviewed/approved by the materials engineer and the contamination control engineer (if any).

4.3.2 Adhesives

Adhesives and solder fluxes shall be compatible with cleaning methods used subsequent to assembly. (See D-8208 and FS504574, Rev. C.) Low outgassing adhesives are to be preferred. Adhesives must be completely cured.

4.3.3 Venting

As a guideline, the specific location and direction of intentional (e.g. de-pressurization) vents and the seams and perforations of multi-layer insulation shall be selected so as to direct any outgas into the field of view of SeaWinds and to avoid the location of other instruments.

4.4 CONTAMINATION CONTROL BY LEVEL OF ASSEMBLY

4.4.1 Piece Parts

Piece parts, other than electronic piece parts, shall be cleaned prior to assembly. Such cleaning shall be documented. Actuators and solenoids, in general, shall be externally cleaned after receipt at JPL. Vacuum conditioning is also required prior to next level of assembly.

4.4.2 Assemblies

Cables and wire harnesses, after fabrication, shall be cleaned, vacuum conditioned, and packaged prior to next level of assembly. Electronics assemblies (P.C. boards) will be assembled in a controlled area and cleaned prior to next assembly (D-8208).

4.4.3 Subsystem (of the instrument) Level

All hardware shall be cleaned and packaged to prevent contamination prior to delivery for system integration. Cleaning, packaging, and handling procedures shall be documented by use of AIDS at JPL or by equivalent assembly instructions at the Contractor.

4.4.4 System (the instrument) Level

Assembly at system level shall be done in a class 100,000 facility. Personnel restrictions will be in effect during these operations. Contamination Control will be in accordance with applicable portions of Seawinds Contamination Control Procedures. Assembly procedures shall be documented by the use of AIDS.

4.5 CONTAMINATION CONTROL FOR SYSTEM TESTING

System level functional testing will normally be performed in a class 100,000 area. Environmental testing shall be planned to limit the exposure of the instrument to uncontrolled environments. Test planning shall be documented by use of AIDS.

4.6 GROUND SUPPORT AND SPECIAL TEST EQUIPMENT

All GSE and STE which either comes into direct contact with or might transfer contamination to an item of flight hardware must be first be cleaned to the same condition as the flight hardware. Specifically any GSE or STE that is introduced into the system level thermal vacuum test chamber must first (separately) be vacuum conditioned to outgas less than the required (if any) final outgas rate of the flight system.

4.7 CLEANING PROCEDURES

Cleaning procedures will vary depending on material (metal, electronics, etc.) and these procedures are generally noted in D-8208 or FS504574, Rev. C. Cleaning solvents that are used shall not leave residues that are deleterious to the Seawinds or contribute to overall contamination. All cleaning procedures shall be approved by the cognizant hardware and Q.A. engineers prior to use.

4.8 BAGS AND CONTAINERS

Bagging materials and techniques, and shipping containers for parts and assemblies and the instrument shall be selected by the hardware cognizant engineer. The contamination control engineer (if any) shall be consulted, in all cases, to assure that the bagging materials meet all the contamination control and antistatic requirements, while providing the required protection. The instrument shipping container shall be cleaned to a level commensurate with the cleanliness achieved for the instrument, as measured. (See section 5.5.)

4.9 KNOWN UNIQUE SITUATIONS

The Seawinds antennas will have unique handling and cleaning constraints that will require careful examination of all assembly and handling/shipping documentation. The mechanism for rotating the antenna may be a large source of outgas.

4.10 SUMMARY OF SPECIFIC CONTAMINATION CONTROL PROCEDURES

The following list establishes the requirements to control and limit other contaminating materials that could affect the proper functioning of the hardware .

1. Detail parts - Bolts, brackets, small mechanical pieces, etc. shall be cleaned prior to the next level of assembly. Solenoids and actuators, and other piece parts (except not electronic components) as identified by the materials engineer, shall be vacuum conditioned prior to the next level of assembly.

2. Mechanisms - Class 100 area (flow bench); clean prior to next level of assembly; vacuum conditioning no later than subsystem level testing

3. Electronics (Boards)- Controlled area; clean prior to next level of assembly; vacuum conditioning no later than subsystem level testing

4. Bonding -
   a) Prior to delivery, bonding of mechanical components shall be done in a controlled area. Cures must be complete.
   b) All bonding in the spacecraft assembly area shall be done in a controlled area. Cures must be complete.

5. Quasioptics test - Class 100,000 control area; clean prior to assembly

6. Quasioptics assembly and subassemblies - Class 10,000

7. Seawinds integration - Class 100,000

8. Seawinds test - Class 100,000 with protective covers on the Seawinds

SECTION 5: CONTAMINATION CONTROL REQUIREMENTS AND PROCEDURES

5.1 CLEANING PROCEDURES

The cleaning procedures for use with SeaWinds components will be primarily those as described in detail in JPL Specification D-8208 or FS504574, Rev. C. Procedure applicability is governed by the material to be cleaned. Each group of incoming parts shall be segregated by material class and run through the appropriate pre-cleaning sequence.

Preliminary operations shall be performed outside the clean facility; for example, all rough and precision machining. Control will be exercised to avoid the use of lubricants during machining which cannot be removed in subsequent cleaning.

Electronics components are procured from outside vendors with no specific contamination control.

These components shall be subjected to a cleaning operation per D-8208, prior to assembly onto printed circuit boards.

Following assembly of the modular electronic subassemblies, the modules shall be cleaned, dried in gaseous nitrogen or outgassed, as appropriate, and sealed in anti-static containers.

5.2 VACUUM CONDITIONING PROCEDURE FOR CONTROL OF MOLECULAR OUTGAS

All assemblies containing nonmetallic materials and/or surface coatings shall undergo vacuum conditioning (a mild bakeout) in accordance with the following table:

ITEM	SCHEDULE	CONDITIONS
Electronics	After test and conformal coating, prior to or during subsystem level testing	PF HOT[1] 10^{-5} torr 24 hours
Mechanisms and Assemblies	After final cleaning, prior to or during subsystem level testing	50˚C $\pm$ 2˚C 10^{-5} torr 48 hours
Antennas	After final cleaning, prior to integration	50˚C $\pm$ 2˚C 10^{-5} torr 24 hours
Multi-layer Insulation (MLI)	Prior to installation	50˚C to 100˚C 10^{-5} torr 48 hours minimum
Solenoids and Actuators	After cleaning, prior to installation into subsystem	PF HOT 10^{-5} torr 48 hours
Cables	Prior to subsystem level testing	PF HOT 10^{-5} torr 48 hours

[1] Protoflight maximum temperature limit

5.3 FACILITIES

The processing and assembly of all interior parts of the Seawinds, as well as the final system assembly and test, shall take place in a room that meets the 100,000 class requirements per Federal Standard 209D. The facility layout shall make allowances for the traffic flow requirements of the operation and provide for contamination barriers where cross-contamination and transfer hazards between operations exist, i.e., the areas for the robing and decontamination of personnel, receiving and inspection, cleaning, and decontamination. The clean assembly areas shall be isolated from each other so that contamination and the flow of materials and equipment, tools and personnel can be positively controlled. Consideration should be given to the proper air flow pattern in the facility layout, or in the choice of an existing facility. The flow should always be directed from the work piece toward the operator. Where laminar flow benches are used, the benches must be positioned in such a manner that they cannot contaminate each other. Vertical flow is the preferred concept for operations that involve larger numbers of people, and where the hardware is worked on predominantly from the side, i.e., systems, assembly, test operations, etc.

5.4 CONSTRAINTS/SELECTION, TRAINING CERTIFICATION FOR SYSTEM INTEGRATION OPERATIONS

Only personnel who have completed a prescribed indoctrination course will be permitted to enter the clean room complex. A maintenance schedule and check list shall be established to guide the operations of maintenance personnel. Visitors shall be escorted, under regulations established for clean room operations.

Personnel shall be required to adhere to entry procedures. They shall be visually observed to ensure compliance with proper dress and use of protective garments. Supervisory personnel shall monitor conduct of clean room and provide for:

1. Stringent conformance to operational procedures (assembly, test, etc.)

2. Avoidance of contaminating actions and material

3. Reporting of accidental contamination

5.5 FINAL CLEANLINESS MEASUREMENT

Although the contamination control of this Plan has been by process control only, without any cleanliness acceptance criteria, prudence suggests that the cleanliness obtained be measured and documented. The pertinent measurements are the particles and the nonvolatile residue (NVR) on the external free surfaces and the outgassing rate of the instrument.

5.5.1 External Surface Particles

After the system thermal-vacuum test and before the instrument is packaged for shipment, the particles on the external surface (typically the MLI) shall be sampled by a standard tape lift procedure (GSFC-TLS-PR-7324-01, or equivalent) at six representative locations. Each sample shall be enumerated per standard size ranges, and the results documented.

5.5.2 NVR

After the system thermal-vacuum test and before the instrument is packaged for shipment, the NVR on the external surface (typically the MLI) shall be sampled by a standard swab procedure (ASTM E1235-88, or equivalent) at three representative locations, one square foot each. The NVR per unit area from the aggregate of these samples shall be determined, and the results documented.

5.5.3 System Outgas Rate

Before the system thermal-vacuum test, a temperature-controlled quartz crystal microbalance (TQCM) shall be mounted inside the vacuum chamber in a location and orientation "looking" at SeaWinds. As part of the test system checkout, the TQCM shall first be operated in the chamber with all GSE and STE in place to determine the rate from everything except SeaWinds. The TQCM shall be operated at -25˚C (or other temperature per the compatibility requirements, if any). The continuous rate as monitored by the TQCM during the system thermal-vacuum test, corrected for the rate from all other sources, shall be documented.

5.6 QUALITY ASSURANCE SURVEILLANCE AND DOCUMENTATION, MATERIAL AND PARTS CLEANING

Quality assurance personnel, in accordance with the SeaWinds Quality Assurance Plan, PD 686-032, shall be responsible for monitoring adherence of operating personnel to the established cleaning procedures. Sufficient documentation will be maintained to ensure that all material admitted for cleaning completes the proper cleaning sequence.

A Quality Assurance Engineer will audit clean room operations to ensure that operating personnel comply with established cleaning procedures. AIDS, or equivalent Contractor assembly instructions, will identify each manufacturing operation. Documentation which accompanies each group of components through the cleaning sequence will identify the parts, materials, and specific cleaning procedure performed.

5.7 QUALITY ASSURANCE SURVEILLANCE OF FACILITY CLEANLINESS

Prior to the start-up of cleaning or assembly operations on the SeaWinds hardware in a clean room, the facility will be certified.

In accordance with established procedures, Quality Assurance will:

- Monitor compliance with clean room cleanliness requirements.
- Ensure adherence to the handling, cleaning, storage, safety, and transporting of SeaWinds material, to the applicable procedures.
- Ensure the proper maintenance to prescribed procedures by performing periodic audits.
- Monitor/Audit compliance with clean room access requirements.

5.8 SAFETY CONSTRAINTS

Safety of personnel and equipment will be monitored by Quality Assurance in accordance with standard JPL safety practices and SeaWinds Safety Plan (PD 686-037).

5.9 SUBCONTRACTOR AND SUPPLIER CONTROLS

Cleanliness requirements are to be established through procurement and other interface documentation with subcontractors and suppliers. Subcontractor contamination control plans, if required, will be reviewed and approved by JPL. Packaging of precision cleaned component parts will be in accordance with MIL-STD-1246B. Where more stringent cleanliness requirements have not been established, all components must be visibly clean and free of perceptible films.